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ABSTRACT

This document presents a study involving 75 pre-service teachers enrolled in introductory biology at the University of Georgia to determine if students who are provided with performance objectives and experience immediate feedback diagnostic testing, achieve differently from students who receive performance objectives but who do not experience diagnostic testing. Results indicate no significant differences in student achievement between groups. Recommendations concerning the use of diagnostic organizers are offered. (SL)

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THE EFFECTS OF ACHIEVEMENT DIAGNOSIS WITH FEEDBACK ON THE SCIENCE ACHIEVEMENT AND ATTITUDE OF UNIVERSITY STUDENTS

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The Effects of Achievement Diagnosis with Feedback on the Science Achievement and Attitude of University Students*

Is instruction effective if students do not become aware of their learning difficulties until after the summative examination?

Most achievement tests are used by instructors for the purpose of determining what students know. An equally viable purpose of testing is to provide feedback to students which identifies that which they do not know (Bloom, Hastings and Madaus, 1971). Formal feedback can pinpoint misconceptions and learning difficulties early enough to allow for correction prior to summative evaluation. In the case of university students, the correction could possible be self-prescribed if they are provided with feedback from diagnosis.

The information gained through the diagnosis and feedback process may serve in an organizing capacity by helping focus students on the important concepts presented in the classroom, and more importantly on the particular concepts with which they may be having difficulty. As stated by Bloom (1974) most students can learn that which we want to teach--if the problem is approached systematically.

In some science classrooms, utilization of written objectives has been shown to be an effective strategy for focusing both the students and the instructor on the important aspects of the material presented (e.g., Olsen, 1973, and Johnson and Sherman, 1975). But, do objectives alone pinpoint for the student what must be accomplished in a course or assist them in identifying learning problems? Can students visualize objectives in terms of what type of item best tests for that objective? Some students probably can, but there will be others who cannot. For these students and others, formative evaluation

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measures used in conjunction with performance objectives may be more effective in terms of increasing student achievement.

In 1968, Bloom proposed a teaching strategy termed "mastery learning" in which he proposed that over 90% of all students could master what is expected of them. Mastery learning has since been the subject in a number of research studies (see Block's review, 1976). In many studies, substantial gains in student achievement have been attained and attributed to the use of the mastery strategy, which involves the development of objectives, a diagnostic-prescriptive process, and reteach-retest remediation activities.

Two problems are readily identified concerning the reteach-retest practices about which mastery learning systems revolve. The first problem is that of the time required to recycle the students. Significant amounts of time are spent in developing materials, and in prescribing each student's specific learning difficulties. The second problem is that of management. Pairing the students with the remedial or enrichment activities, checking on progress, reassessing further problems or determining achievements, reassigning remedial or enrichment activities, and so on, are formidable tasks. Situations which can accommodate these reteach-retest practices do exist, and instructors with the requisite management skills required to utilize systems of reteach-retest with minimal problems are available. However, there are also situations in which, for whatever reasons, reteach-retest procedures can not be employed.

An alternative, systematic approach to the relatively involved system embodied in the mastery learning philosophy was the subject of this study. This alternative approach uses the concept of diagnostic organizers, which involves the use of performance objectives, and the administration of diagnostic testing with immediate feedback. Following the feedback, normal student-teacher interaction provides the student with assistance on specific problems identified

by the diagnostic testing. No formal reteaching is attempted, and no retesting other than the final unit examination is used. In essence, the diagnostic tests are intended to provide organizing information relative to achievement on performance objectives by providing students with the necessary feedback concerning how well they are achieving specific objectives. If objective referenced diagnostic testing can be effective in raising the level of student achievement, and in eliminating some problems associated with limited time and manageability, then its simplicity should contribute to its practicability with regard to adoption in learning situations.

RESEARCH QUESTIONS

Will university students who are provided with performance objectives and experience objective-related diagnostic testing designed to provide immediate feedback, achieve differently than students who are provided with performance objectives but do not experience diagnostic testing? Also, will students' attitudes toward instruction be influenced by the use of diagnostic testing?

PROCEDURES

Data Sources

The subjects in the study were seventy-five pre-service teachers enrolled in four sections of an introductory biology course at the University of Georgia. Pre-treatment data were collected on the average achievement level of each student on the units of study covered prior to experiment conditions. These data were used as covariates to adjust for selection bias and to increase the statistical power of the analyses. Pre-treatment data were also collected on student ability level as assessed by SAT scores.

Post-treatment science achievement data were collected at the end of two units--one on Animal Behavior and one on Ecological Principles. The affective data were collected at the end of the experimental conditions to assess the students' attitudes toward the nature of the instruction which they had experienced. All measures were locally developed and pilot tested to insure adequate reliability and validity. A panel of three science educators judged the content validity of the achievement tests by assessing the degree to which the performance objectives were measured. Items were rewritten until all objectives were represented. The split-half reliabilities of the measures were .72 for the Animal Behavior Test, and .70 for the Ecological Principles Test.

Treatment Levels

The treatment in this study consisted of two levels:

> LEVEL I-OBJECTIVES ONLY - Subjects in this level received a set of performance objectives prior to instruction for each unit of study during the experimental period (this was an established procedure in the course). The subjects were not administered any diagnostic measures nor did they receive any formal feedback prior to summative testing for the unit of study.
>
> LEVEL II-OBJECTIVES AND DIAGNOSIS - Subjects in this level received the same performance objectives as Level I. In addition, at the end of each class period, they completed a diagnostic quiz over all the objectives covered during the immediate session. A self-correcting key was attached to the back side of each quiz which allowed the students to immediately assess their achievement on the session's objectives. All experimental subjects understood that the diagnostic quizzes were not used for grading purposes. No formal reteaching of concepts occurred.

One instructor planned for and taught both the experimental and comparison sections during a unit and another instructor taught all sections in the following unit. The same instructors were involved both quarters.

The experimental or comparison condition was randomly assigned to course sections. There were no evidence that enrollment in a section was systematically biased in terms of student variables; therefore, the unit of

analysis used in the study was the student. Two sections were involved one quarter and two more in a following quarter. This effectively allowed for a replication of the study. The treatment was administered over two complete units of instruction each quarter. A summative measure was taken at the end of each unit.

RESULTS

As mentioned above, the study was conducted and then replicated in the following quarter. Both the ANOVA and ANCOVA procedures supported the same decisions related to hypotheses testing with very little adjustment for selection bias on the covariates. Therefore, the actual achievement means with ANOVA results for each quarter are reported in this section.

Mean achievement scores on the Animal Behavior unit for both studies are given in Table 1. Analysis of these data indicated non-significant treatment effects ($p = .15$, and $p = .99$). A significant Treatment X Ability interaction was found (see Table 2). In order to determine the nature of this interaction, the cell means were graphed as Figure 1 which indicates that the influence of the treatment was not consistent across ability levels. The analysis of ability group effect indicated that neither ability group significantly outperformed the other in either quarter of the study.

Table 3 shows the mean achievement scores on the Ecological Principles unit. The F ratios from the ANOVA procedures indicate significant treatment effects in favor of the experimental group in both studies ($p < .01$) (see Table 4). No Treatment X Ability interactions occur in these data. Also, neither ability group outperformed the other to a significant extent.

Three attitude instruments were used to collect the following affective data for the study: (1) responses from the "objectives only" group on their perceptions of the value of diagnostic feedback, (2) responses from

Table 1

Cell, Marginal, and Grand Mean Scores for Achievement in the Animal Behavior Unit

		Ability		
		High	Low	
First Quarter N = 30	Objectives + Diagnosis	46.6	43.6	45.4
	Objectives Only	40.9	45.3	43.1
		44.8	44.2	44.5
Second Quarter N = 45	Objectives + Diagnosis	44.0	44.0	44.0
	Objectives Only	44.4	43.4	43.7
		44.0	43.7	43.9

Table 2

Analysis of Variance on Animal Behavior Unit Examination Scores for Original and Replicate Study

	Sources	Degrees of Freedom	Mean Squares	F Ratios	P Level
First Quarter	Treatment	1	30.03	2.13	0.15
	Ability	1	1.89	0.13	0.99
	T X A	1	90.47	6.40	0.02
	Residual	26	14.13		
Second Quarter	Treatment	1	.12	.01	0.99
	Ability	1	1.10	.06	0.99
	T X A	1	2.30	.13	0.99
	Residual	41	17.90		

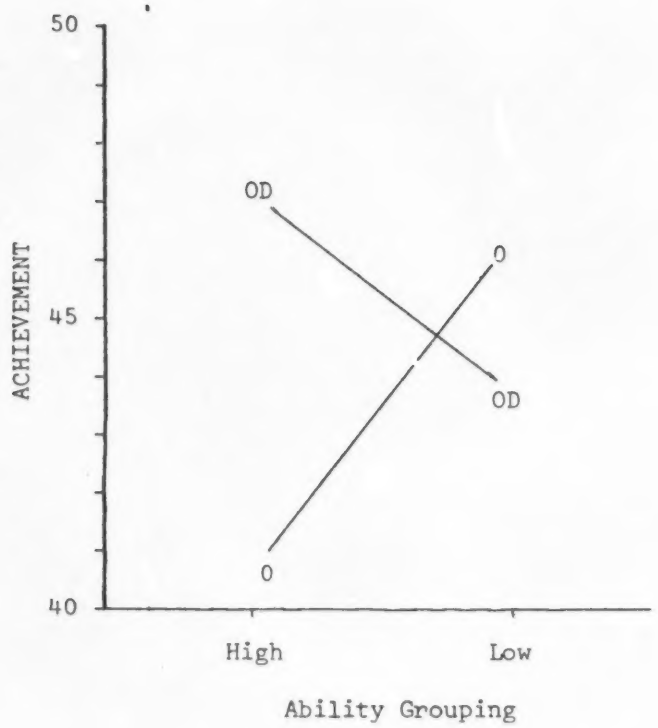

Figure 1. Treatment X Ability interaction on the Animal Behavior unit examination during the first quarter.

Table 3

Cell, Marginal, and Grand Mean Scores for Achievement in the Ecological Principles Unit

		Ability		
		High	Low	
First Quarter N = 30	Objectives + Diagnosis	40.5	37.4	39.2
	Objectives Only	33.6	35.0	34.3
		38.4	36.6	37.5
Second Quarter N = 45	Objectives + Diagnosis	39.8	39.0	39.6
	Objectives Only	36.8	34.3	35.0
		39.2	36.2	37.8

Table 4

Analysis of Variance on Ecological Principles Unit Examination Scores for Original and Replicate Study

	Sources	Degrees of Freedom	Mean Squares	F Ratios	P Level
First Quarter	Treatment	1	151.38	8.20	.01
	Ability	1	18.85	1.02	.32
	T X A	1	33.65	1.82	.19
	Residual	26	18.57		
Second Quarter	Treatment	1	137.61	6.25	.01
	Ability	1	19.93	.91	.99
	T X A	1	6.68	.30	.99
	Residual	41	22.01		

the "objectives with diagnosis" group on the value of diagnostic feedback and the use of it during the two units, and (3) responses to identical items from both groups on their attitude toward the objectives and instruction for the two units.

The attitude measures were composed of Likert type items with five response categories. All items were phrased such that the most positive response (strongly agree) would receive a numerical assignment of 5, and the most negative response (strongly disagree) would receive a numerical assignment of 1. A brief synopsis of the instruments and the student mean responses to them are presented in Tables 5, 6, and 7.

Table 5

Results from the Attitude Questionnaire Administered to the Objectives + Diagnosis Group

	Abbreviated Item	Mean Response	Standard Deviation
1.	Diagnostic test questions helped learning.	4.6	.50
2.	Learned more with diagnostic tests.	4.2	.75
3.	Diagnostic questions clearly related to objectives.	4.7	.49
4.	Diagnostic tests helped organize study.	4.0	.92
5.	Diagnostic tests related to exams.	4.3	.79
6.	Diagnostic tests followed lecture closely.	4.6	.50
7.	Seeing examples of questions indicated by objectives is helpful.	4.5	.60
8.	Want diagnostic tests used in future.	4.6	.60
9.	Time for diagnostic test worthwhile.	4.5	.69
10.	Discussion of diagnostic test results was helpful.	4.2	.95

Table 6

Results from the Attitude Questionnaire Administered to the Objectives Only Group

Abbreviated Item	Mean Response	Standard Deviation
1. Examples of questions testing objectives would benefit.	4.6	0.7
2. Should make change like #1 in this class.	3.0	1.1
3. Short daily quiz (not graded) would be helpful in study.	4.5	0.7
4. Should make change like #3 in this class.	3.5	1.0
5. Feedback from short daily quiz (not graded) would pinpoint misunderstandings.	4.7	0.5

Table 7

Results of the Attitude Questionnaire Administered to Both Treatment Groups

	Abbreviated Item	Objectives + Diagnosis Mean	Objectives Only Mean	t
1.	Presentations by instructors aided in learning.	4.7	4.6	.26
2.	Objectives helped organize study.	4.9	4.6	1.30
3.	Quizzes and tests related to objectives.	4.4	4.2	.46
4.	Always knew what and how to study.	4.1	3.9	.63
5.	Texts, film, etc. helpful to study.	3.8	4.1	1.10
6.	Demonstrations and student activities helped learning.	4.4	4.6	.82
7.	Useful information learned about the topics.	4.4	4.2	.94
8.	Both units helped in learning science procedures.	4.1	4.0	.57
9.	Changing instructors was good.	2.8	3.2	1.30
10.	Enough feedback was available.	4.2	4.6	1.40

$.05 t_{60} = 2.00$

DISCUSSION

Of the two units studied, the first, Animal Behavior, showed no significant increase in student achievement resulting from the use of diagnostic testing in either the original or replicate study. However, during the latter unit, Ecological Principles, significant increases in student achievement favored the diagnostic feedback treatment in both studies. Perhaps this is an indication that students do not immediately become completely aware of the function and proper usage of the diagnostic tests (studies are presently being planned to test this hypothesis). Or, this may be a reflection of the level, or type of understanding which was tested. All groups did score consistently higher on the Behavior tests when compared to the Ecological Principles measures.

The single statistical interaction of treatment with ability may have been due to the fact that subjects from the lower ability group in the diagnostic treatment were not only unable to utilize the diagnostic tests effectively during the first unit in which they were employed, but were actually confused by the use of the tests to the point of not achieving as well as they normally might have. But this conclusion must be viewed as very tentative because the replicate study did not show the interaction.

The original and replicated results from the Ecological Principles interaction unit in this study support the positive influence of diagnostic feedback. In previous studies, student achievement was increased through the use of diagnostic testing followed by some type of formal remediation and subsequent retesting (e.g., Goodson and Okey, 1970, Block and Tunney, 1974, and Block, 1976). Results from the present study suggest that university student science achievement after subjects become accustomed to the process may be accomplished through the use of diagnostic testing with no formal

remediation. If these results can be shown to be more consistent across topics, a teaching strategy which is less time consuming to develop and more practical to implement than those involving reteach-retest cycling could be employed.

The attitude data are both puzzling and enlightening. What might cause the "no feedback" group to feel as positive about the amount of feedback as the "feedback" group. Perhaps this was due to the small size of the groups (< 25) resulting in a more individualized classroom setting. What caused all of the students to react favorably to either the idea, or the actual use of diagnostic testing? The most probable interpretation of this finding is that students appreciate the help and feedback which diagnostic testing is capable of offering. It should be noted that all of the attitudes measured were positive and that where the added achievement occurred, it was not at the expense of the affective objectives of the course.

Two recommendations are offered concerning the use of diagnostic organizers as employed in this study. In order to effectively utilize this system, careful planning must precede instruction. Among the factors to consider are: (1) the proper objective sequence, (2) the number of objectives which can be taught in a class period, and (3) the time which must be allowed for the administration of the diagnostic measures. In addition, once the planning has been done, adherance to the schedule must be strict. Thus, both recommendations involve effective utilization of time: (1) pre-planning, and (2) strict adherance to a schedule.

At this point, several remarks should be directed toward the use of diagnostic testing in this study. The simple difference between the two treatments appears to be the diagnostic testing procedure. Yet, the experience of taking diagnostic tests may not be solely responsible for the increase in student achievement. The actual difference between the two treatments may be

attributable to some combined effort of using performance objectives in conjunction with objective-related diagnostic tests (e.g., the diagnostic organizer concept). A determination of the singular influence of diagnostic testing was beyond the limitations of this study. Therefore, further research is needed to make such an assessment to clearly establish the usefulness of either or both of these applications of diagnostic testing.

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